CLIENTS | PEOPLE | PERFORMANCE

Dairy Unit

PRK 2561 BLDG 004 EQ2

Detailed Engineering Evaluation

Qualitative Report

Version FINAL

75 Lower Styx Road, Bottle Lake

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

Dairy Unit
PRK 2561 BLDG 004 EQ2

Detailed Engineering Evaluation
Qualitative Report
Version FINAL

75 Lower Styx Road, Bottle Lake

Christchurch City Council

Prepared By
Peter O'Brien

Reviewed By
Hamish Mackinven

Date
18th December 2013

Contents

Table Index

Figure Index

Appendices

Qualitative Report Summary

Dairy Unit

PRK 2561 BLDG 004 EQ2

Detailed Engineering Evaluation

Qualitative Report - SUMMARY

Version FINAL

75 Lower Styx Road, Bottle Lake, Christchurch

Background

This is a summary of the Qualitative report for the building structure, and is based in part on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011 and visual inspections on 16th April 2012.

Building Description

The dairy unit is located at 75 Lower Styx Road, Bottle Lake, Christchurch. The exact date of construction is unknown but it is known to be pre-1964 as an extension in the form of a tanker room was added to the northeast of the existing dairy unit/cow shed.

The original portion of the building is of reinforced concrete construction to approximately 1.3m and timber framed construction above to roof level. The roof of the older portion of the building is corrugated iron on timber roof joists. The timber framed portions of the walls are suspected to be asbestos lined internally and externally. Foundations are concrete strip footings. Floors are concrete slab on grade.

The 1963 extension is of reinforced concrete construction to roof level. The roof is constructed of corrugated iron on timber rafters spanning from south-east to north-west. Ground floor consists of a reinforced concrete slab elevated to approximately 0.9m above ground level and supported by the external walls. Foundations consist of concrete strip footings.

Key Damage Observed

- No earthquake related damage was noted to the building
- Cracking to the wall linings was noted

Critical Structural Weaknesses

The following potential critical structural weaknesses have been identified in the structure.

- Plan Irregularity (30% Reduction)
- Liquefaction Potential (30% Reduction)

} 7% NBS

Indicative Building Strength (from IEP and CSW assessment)

Based on the information available, and using the NZSEE Initial Evaluation Procedure, the original capacity of the building has been assessed to be in the order of 7% NBS and post-earthquake capacity also in the order of 7% NBS. The building's post-earthquake capacity excluding critical structural weaknesses is in the order of 15% NBS.

The building has been assessed to have a seismic capacity in the order of 7% NBS and is therefore considered to be potentially Earthquake Prone.

Recommendations

The recent seismic activity in Christchurch has caused no visible damage to the building. However, as the building has achieved less than 34% NBS following a qualitative Detailed Engineering Evaluation of the building, further assessment is required. It is recommended that a quantitative assessment be carried out and if necessary strengthening options explored.

The building should not be occupied as per CCC policy regarding the occupancy of potentially Earthquake Prone buildings.

1. Background

GHD has been engaged by the Christchurch City Council (CCC) to undertake a detailed engineering evaluation of the dairy unit at 75 Lower Styx Road.

This report is a Qualitative Assessment of the building structure, and is based in part on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011.

A qualitative assessment involves inspections of the building and a desktop review of existing structural and geotechnical information, including existing drawings and calculations, if available.

The purpose of the assessment is to determine the likely building performance and damage patterns, to identify any potential critical structural weaknesses or collapse hazards, and to make an initial assessment of the likely building strength in terms of percentage of new building standard (%NBS).

At the time of this report, no intrusive site investigation, detailed analysis, or modelling of the building structure had been carried out. Construction drawings were made available, and these have been considered in our evaluation of the building. The building description is based on a review of the drawings and our visual inspections.

2. Compliance

This section contains a brief summary of the requirements of the various statutes and authorities that control activities in relation to buildings in Christchurch at present.

2.1 Canterbury Earthquake Recovery Authority (CERA)

CERA was established on 28 March 2011 to take control of the recovery of Christchurch using powers established by the Canterbury Earthquake Recovery Act enacted on 18 April 2011. This act gives the Chief Executive Officer of CERA wide powers in relation to building safety, demolition and repair. Two relevant sections are:

Section 38 – Works

This section outlines a process in which the chief executive can give notice that a building is to be demolished and if the owner does not carry out the demolition, the chief executive can commission the demolition and recover the costs from the owner or by placing a charge on the owners' land.

Section 51 – Requiring Structural Survey

This section enables the chief executive to require a building owner, insurer or mortgagee carry out a full structural survey before the building is re-occupied.

We understand that CERA will require a detailed engineering evaluation to be carried out for all buildings (other than those exempt from the Earthquake Prone Building definition in the Building Act). It is anticipated that CERA will adopt the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011. This document sets out a methodology for both qualitative and quantitative assessments.

The qualitative assessment is a desk-top and site inspection assessment. It is based on a thorough visual inspection of the building coupled with a review of available documentation such as drawings and specifications. The quantitative assessment involves analytical calculation of the buildings strength and may require non-destructive or destructive material testing, geotechnical testing and intrusive investigation.

It is anticipated that factors determining the extent of evaluation and strengthening level required will include:

- The importance level and occupancy of the building
- The placard status and amount of damage
- The age and structural type of the building
- Consideration of any critical structural weaknesses
- The extent of any earthquake damage

2.2 Building Act

Several sections of the Building Act are relevant when considering structural requirements:

Section 112 – Alterations

This section requires that an existing building complies with the relevant sections of the Building Code to at least the extent that it did prior to any alteration. This effectively means that a building cannot be weakened as a result of an alteration (including partial demolition).

Section 115 – Change of Use

This section requires that the territorial authority (in this case Christchurch City Council (CCC)) be satisfied that the building with a new use complies with the relevant sections of the Building Code 'as near as is reasonably practicable'. Regarding seismic capacity 'as near as reasonably practicable' has previously been interpreted by CCC as achieving a minimum of 67% NBS however where practical achieving 100% NBS is desirable. The New Zealand Society for Earthquake Engineering (NZSEE) recommend a minimum of 67% NBS.

2.2.1 Section 121 – Dangerous Buildings

The definition of dangerous building in the Act was extended by the Canterbury Earthquake (Building Act) Order 2010, and it now defines a building as dangerous if:

- In the ordinary course of events (excluding the occurrence of an earthquake), the building is likely to cause injury or death or damage to other property; or
- In the event of fire, injury or death to any persons in the building or on other property is likely because of fire hazard or the occupancy of the building; or
- There is a risk that the building could collapse or otherwise cause injury or death as a result of earthquake shaking that is less than a 'moderate earthquake' (refer to Section 122 below); or
- There is a risk that that other property could collapse or otherwise cause injury or death; or
- A territorial authority has not been able to undertake an inspection to determine whether the building is dangerous.

Section 122 – Earthquake Prone Buildings

This section defines a building as earthquake prone if its ultimate capacity would be exceeded in a 'moderate earthquake' and it would be likely to collapse causing injury or death, or damage to other property. A moderate earthquake is defined by the building regulations as one that would generate ground shaking 33% of the shaking used to design an equivalent new building.

Section 124 – Powers of Territorial Authorities

This section gives the territorial authority the power to require strengthening work within specified timeframes or to close and prevent occupancy to any building defined as dangerous or earthquake prone.

Section 131 – Earthquake Prone Building Policy

This section requires the territorial authority to adopt a specific policy for earthquake prone, dangerous and insanitary buildings.

2.3 Christchurch City Council Policy

Christchurch City Council adopted their Earthquake Prone, Dangerous and Insanitary Building Policy in 2006. This policy was amended immediately following the Darfield Earthquake of the 4th September 2010.

The 2010 amendment includes the following:

- A process for identifying, categorising and prioritising Earthquake Prone Buildings, commencing on 1 July 2012;
- A strengthening target level of 67% of a new building for buildings that are Earthquake Prone;
- A timeframe of 15-30 years for Earthquake Prone Buildings to be strengthened; and,
- Repair works for buildings damaged by earthquakes will be required to comply with the above.

The council has stated their willingness to consider retrofit proposals on a case by case basis, considering the economic impact of such a retrofit.

We anticipate that any building with a capacity of less than 33% NBS (including consideration of critical structural weaknesses) will need to be strengthened to a target of 67% NBS of new building standard as recommended by the Policy.

If strengthening works are undertaken, a building consent will be required. A requirement of the consent will require upgrade of the building to comply 'as near as is reasonably practicable' with:

- The accessibility requirements of the Building Code.
- The fire requirements of the Building Code. This is likely to require a fire report to be submitted with the building consent application.

2.4 Building Code

The building code outlines performance standards for buildings and the Building Act requires that all new buildings comply with this code. Compliance Documents published by The Department of Building and Housing can be used to demonstrate compliance with the Building Code.

After the February Earthquake, on 19 May 2011, Compliance Document B1: Structure was amended to include increased seismic design requirements for Canterbury as follows:

- Hazard Factor increased from 0.22 to 0.3 (36% increase in the basic seismic design load)
- Serviceability Return Period Factor increased from 0.25 to 0.33 (80% increase in the serviceability design loads when combined with the Hazard Factor increase)

The increase in the above factors has resulted in a reduction in the level of compliance of an existing building relative to a new building despite the capacity of the existing building not changing.

3. Earthquake Resistance Standards

For this assessment, the building's earthquake resistance is compared with the current New Zealand Building Code requirements for a new building constructed on the site. This is expressed as a percentage of new building standard (%NBS). The new building standard load requirements have been determined in accordance with the current earthquake loading standard (NZS 1170.5:2004 Structural design actions - Earthquake actions - New Zealand).

The likely capacity of this building has been derived in accordance with the New Zealand Society for Earthquake Engineering (NZSEE) guidelines 'Assessment and Improvement of the Structural Performance of Buildings in Earthquakes' (AISPBE), 2006. These guidelines provide an Initial Evaluation Procedure that assesses a buildings capacity based on a comparison of loading codes from when the building was designed and currently. It is a quick high-level procedure that can be used when undertaking a Qualitative analysis of a building. The guidelines also provide guidance on calculating a modified Ultimate Limit State capacity of the building which is much more accurate and can be used when undertaking a Quantitative analysis.

The New Zealand Society for Earthquake Engineering has proposed a way for classifying earthquake risk for existing buildings in terms of %NBS and this is shown in Figure 1 below.

Description	Grade	Risk	%NBS	Existing Building Structural Performance	Improvement of Structural Performance	
					Legal Requirement	NZSEE Recommendation
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)	The Building Act sets no required level of structural improvement (unless change in use) This is for each TA to decide. Improvement is not limited to 34%NBS.	100%NBS desirable. Improvement should achieve at least 67%NBS
Moderate Risk Building	B or C	Moderate	34 to 66	Acceptable legally. Improvement recommended		Not recommended. Acceptable only in exceptional circumstances
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement	Unacceptable	Unacceptable

Figure 1 NZSEE Risk Classifications Extracted from table 2.2 of the NZSEE 2006 AISPBE

Table 1 compares the percentage NBS to the relative risk of the building failing in a seismic event with a 10% risk of exceedance in 50 years (i.e. 0.2% in the next year). It is noted that the current seismic risk in Christchurch results in a 6% risk of exceedance in the next year.

Percentage of New Building Standard (%NBS)	Relative Risk (Approximate)
>100	<1 time
80-100	1-2 times
67-80	2-5 times
33-67	5-10 times
20-33	10-25 times
<20	>25 times

Table 1 %NBS compared to relative risk of failure

4. Building Description

4.1 General

The building in question is the dairy unit located at 75 Lower Styx Road, Bottle Lake, Christchurch. The exact date of construction of the building is unknown but it is known to be pre-1963 as an extension to an existing dairy unit/cow shed was added in 1963. The building is currently unused. There are 6 buildings located on the site with various uses.

The original portion of the building is of reinforced concrete construction to approximately 1.3m and timber framed construction above to roof level. The roof of the older portion of the building is corrugated iron on timber roof joists spanning between the original south-west and north-east walls with intermediate support provided by the internal timber framed wall and a steel post as shown in Figure 2. The timber framed portions of the walls are lined internally and externally with what is believed to be asbestos linings. The reinforced concrete portions of the walls are unfinished internally with a textured plaster finish to the exterior. Foundations are concrete strip footings. Floors are concrete slab on grade.

The 1963 extension is of reinforced concrete construction to roof level. The roof is constructed of corrugated iron on timber rafters spanning from south-east to north-west. The reinforced concrete walls are unlined internally and finished with a textured plaster finish externally. The ground floor consists of a reinforced concrete slab elevated to approximately 0.9m above ground level and supported by the external walls. Foundations consist of concrete strip footings underneath external walls.

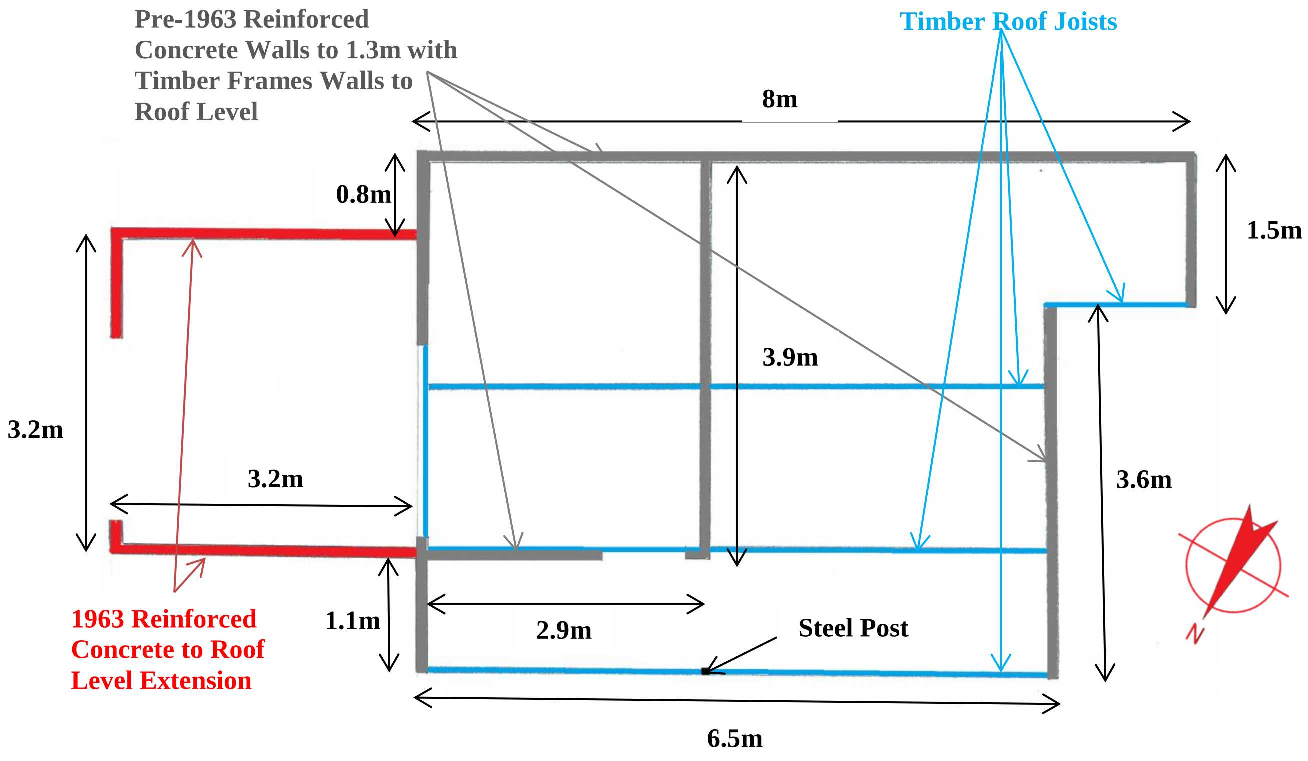


Figure 2 Plan Sketch Showing Key Structural Elements

The dimensions of the building are approximately 11.2m in length, 5.1m in width and 3.6m and 2.3m in height for the 1963 extension and the older portion of the building respectively. The plan area of the building is approximately 46m^2.

The nearest building to the dairy unit is the storage shed approximately 17m to the north. The closest waterway is the Styx River approximately 45m to the west. The site is predominantly flat with insignificant variations in the ground levels throughout.

4.2 Gravity Load Resisting System

In the original portion of the building the gravity loads are transferred from the metal roof cladding to timber purlins and into the timber roof joists. The roof joists are supported by the external and internal load bearing timber framed walls. An exception to this is the roof joist spanning along the northern edge of the building which is supported by the external timber framed walls and a steel post (See Figure 2). Loads transferred through the external timber frame walls are then transmitted through to the concrete external walls and on to the concrete strip foundations and then to the ground below. Internal loads are transferred directly through to the concrete floor slab and through to the ground below.

Roof loads of the 1963 extension are transferred from the iron cladding to the timber purlins. The purlins transfer the load to the rafter at the apex of the roof and the external concrete walls. The concrete walls transfer the loads on to the concrete strip foundations and then to the ground below. Internal loads are transferred directly through to the concrete floor slab, then through the slab to the supporting external concrete walls and through to the ground below.

4.3 Lateral Load Resisting System

4.3.1 Pre-1963 Portion

Longitudinal

Roof bracing members could not be seen in the roof due to the cladding. Due to the presence of a large opening in the north-western wall of the building roof bracing would be required to transfer lateral loads back to the supporting walls. Nominal roof bracing provided by the timber sarking and roof purlins/joists transfers the lateral loads to the perimeter walls.

Lateral loads from roof level are transferred to the supporting, timber framed rear wall. Lateral loads are transferred through the timber framed wall to the reinforced concrete wall below and on to the concrete strip foundations and then to the ground below. Torsional loads are resisted by the opposing transverse walls.

Transverse

Similarly to the longitudinal direction loads from roof level are transferred to the supporting external and internal, timber framed walls. Diagonal timber bracing in the timber framed walls could not be confirmed due to the presence of wall linings. Nominal bracing is provided by the diaphragm/sheet action of the wall linings. Loads are transferred through the timber framed walls to the reinforced concrete wall below and on to the concrete strip foundations and then to the ground below.

4.3.2 1963 Extension

Roof cladding is expected to provide some nominal roof bracing, transferring lateral loads to the perimeter walls. On three sides the reinforced concrete walls transfer loads to the ground in shear. On the fourth side, the asbestos sheet lining transfers the loads down to the lower concrete wall and through to the ground.

5. Assessment

An inspection of the building was undertaken on the 16th of April 2012. Both the interior and exterior of the building were inspected.

The inspection consisted of scrutinising the building to determine the structural systems and likely behaviour of the building during an earthquake. The site was assessed for damage, including examination of the ground conditions, checking for damage in areas where damage would be expected for the type of structure and noting general damage observed throughout the building in both structural and non-structural elements.

The %NBS score determined for this building has been based on the IEP procedure described by the NZSEE and based on the information obtained from visual observation of the building and available drawings.

6. Damage Assessment

6.1 Surrounding Buildings

The dairy unit at 75 Lower Styx Road is located in a rural area with 5 other buildings. These buildings are a house, a garage, a hay barn, a storage shed and a barn. There did not appear to be any earthquake related damage to any of these structures.

6.2 Residual Displacements and General Observations

No residual displacements of the structure were noticed during our inspection of the building.

The only damage noted to the building was cracking to the suspected asbestos wall linings but this is not believed to be as a result of the earthquakes. It is not expected that the damage to the linings will have a negative effect on the structural capacity of the building. The % NBS of the building has not been reduced as a result of this damage.

6.3 Ground Damage

There was no evidence of ground damage on the property. Neighbouring land to the southwest, at 51 Lower Styx Road, was severely affected by lateral spreading.

7. Critical Structural Weakness

7.1 Short Columns

No significant short columns are present in the structure.

7.2 Lift Shaft

The building does not contain a lift shaft.

7.3 Roof

No roof bracing was visible. Roof elements such as cladding, rafters and roof joists are expected to provide some bracing to the roof structure in the form of diaphragm action. However; the lack of visible bracing in conjunction with a large opening in the north-western elevation constitutes a critical structural weakness in the form of plan irregularity (section 7.6).

7.4 Staircases

The building does not contain a staircase.

7.5 Site Characteristics

Based on the findings of the geotechnical appraisal it was found that the site has a moderate to high potential for liquefaction. For the purposes of the IEP assessment of the building and the determination of the %NBS score, the effects of soil liquefaction on the performance of the building has been assessed as a 'significant' site characteristic in accordance with the NZSEE guidelines.

7.6 Plan Irregularity

The presence of large openings in the north-western side of the building in conjunction with only nominal roof bracing results in a 'significant' plan irregularity critical structural weakness.

8. Geotechnical Consideration

8.1 Site Description

The site at 75 Lower Styx Road is situated in Bottle Lake, just north of Christchurch City. It is situated between the Styx River and Lower Styx Road, and is relatively flat at approximately 3m above mean sea level. It is approximately 4km south of the Waimakariri River, and 4km west of the coast (Pegasus Bay).

8.2 Published Information on Ground Conditions

8.2.1 Published Geology

The geological map of the area[1] indicates that the site to be on or near the boundary of the following units:

- grey river alluvium, comprising gravel, sand and silt, in active floodplains, Holocene in age; and,
- beach sand or river sand dunes, Holocene in age.

8.2.2 Environment Canterbury Logs

Information from Environment Canterbury (ECan) indicates that three boreholes are located within a 200m radius of the site. Of these boreholes, two of them had lithographic logs (see Table 2), which indicate the area is typically underlain by 30m of sand and gravel. The logs also indicate the potential presence of strata containing peat at approximately 27m below ground level (bgl).

Table 2 ECan Borehole Summary

Bore Name	Log Depth	Groundwater	Distance & Direction from Site
M35/9747	30.0m	0.30m bgl	150m NE of the site
M35/11929	32.5m	0.72m bgl	150m SW of the site

It should be noted that the purpose of the boreholes the well logs are associated with, were sunk for groundwater extraction and not for geotechnical purposes. Therefore, the amount of material recovered and available for interpretation and recording will have been variable at best and may not be representative. The logs have been written by the well driller and not a geotechnical professional or to a standard. In addition strength data is not recorded.

8.2.3 EQC Geotechnical Investigations

The Earthquake Commission has not undertaken geotechnical testing in the area of the subject site.

[1] Forsyth P.J., Barrell D.J.A., & Jongens R. 2008: *Geology of the Christchurch Area*. Institute of Geological and Nuclear Sciences 1:250,000 Geological Map 16. Lower Hutt. Institute of Geological and Nuclear Sciences Limited.

8.2.4 Land Zoning

Canterbury Earthquake Recovery Authority (CERA) has published areas showing the Green Zone Technical Category in relation to the risk of future liquefaction and how these areas are expected to perform in future earthquakes.

The site is classified as Green Zone, indicating the land is generally suitable for repair and rebuilding to take place. It is also categorised Technical Category Not Applicable (rural & unmapped), as the property is considered non-residential.

8.2.5 Post February Aerial Photography

Aerial photography taken following the 22 February 2011 earthquake doesn't show clear signs of liquefaction (see Figure 3), however, liquefaction was observed close to the property.

Figure 3 Post February 2011 Earthquake Aerial Photography [2]

8.2.6 Summary of Ground Conditions

From the information presented above, the ground conditions underlying the site are anticipated to comprise beach sands and gravels. However, due to the limited information available, this is subject to confirmation.

[2] Aerial Photography Supplied by Koordinates sourced from http://koordinates.com/layer/3185-christchurch-post-earthquake-aerial-photos-24-feb-2011/

8.3 Seismicity

8.3.1 Nearby Faults

There are many faults in the Canterbury region, however only those considered most likely to have an adverse effect on the site are detailed below.

Table 3 Summary of Known Active Faults[3,4]

Known Active Fault	Distance from Site	Direction from Site	Max Likely Magnitude	Avg Recurrence Interval
Alpine Fault	130 km	NW	~8.3	~300 years
Greendale (2010) Fault	30 km	SW	7.1	~15,000 years
Hope Fault	100 km	N	7.2~7.5	120~200 years
Kelly Fault	110 km	NW	7.2	150 years
Porters Pass Fault	60 km	NW	7.0	1100 years

Recent earthquakes since 22 February 2011 have identified the presence of a previously unmapped active fault system underneath Christchurch City and the Port Hills. Research and published information on this system is in development and not generally available. Average recurrence intervals are yet to be estimated.

8.3.2 Ground Shaking Hazard

This seismic activity has produced earthquakes of Magnitude-6.3 with peak ground accelerations (PGA) up to twice the acceleration due to gravity (2g) in some parts of the city. This has resulted in widespread liquefaction throughout Christchurch.

New Zealand Standard NZS 1170.5:2004 quantifies the Seismic Hazard factor for Christchurch as 0.30, being in a moderate to high earthquake zone. This value has been provisionally upgraded recently (from 0.22) to reflect the seismicity hazard observed in the earthquakes since 4 September 2010.

In addition, anticipation of marine and/or estuarine sands of varying density, a 475-year PGA (peak ground acceleration) of ~0.4 (Stirling et al, 2002[4]), and bedrock anticipated to be in excess of 500m deep, and hence ground shaking is likely to be relatively high.

[3] Stirling, M.W, McVerry, G.H, and Berryman K.R. (2002) A New Seismic Hazard Model for New Zealand, Bulletin of the Seismological Society of America, Vol. 92 No. 5, pp 1878-1903, June 2002.

[4] GNS Active Faults Database

8.4 Slope Failure and/or Rockfall Potential

Given the site's location in a flat area northeast of Christchurch, global slope instability is considered negligible. However, the Styx River may be susceptible to lateral spreading, as evident to the north in Spencerville following the 4th September 2010 and 22nd February 2011 earthquakes.

In addition, any localised retaining structures or embankments should be further investigated to determine the site-specific slope instability potential.

8.5 Liquefaction Potential

Due to the anticipated presence of sand at the shallow depth, and the sites proximity to a local water course, it is considered possible that liquefaction will occur at the site. It is not clear from the post-earthquake aerial photography (Figure 3) whether liquefaction has occurred at the site, however, it was observed close to the property. The site is considered to have a moderate-high liquefaction potential at this stage of investigation.

This liquefaction may occur in the form of sand boils, lateral spreading or both.

Ground Investigation should be undertaken to establish the liquefaction potential of the site and allow a comprehensive liquefaction assessment to be undertaken.

8.6 Recommendations

A soil class of **D** (in accordance with NZS 1170.5:2004) should be adopted for the site.

It is recommended that three piezocone CPTs be conducted to target depths of 20m. This will allow a liquefaction assessment to be carried out.

8.7 Conclusions & Summary

This assessment is based on a review of the geology and existing ground investigation information, and observations from the Christchurch earthquakes since 4 September 2010.

The site is anticipated to be situated predominantly on sand and gravel. Associated with this the site also has a moderate-high liquefaction potential. This may also arise in the form of lateral spreading on the Styx River.

A soil class of **D** (in accordance with NZS 1170.5:2004) should be adopted for the site.

It is recommended that intrusive investigation comprising three piezocone CPTs be conducted to target depths of 20m.

9. Survey

No level or verticality surveys have been undertaken for this building at this stage in accordance with Christchurch City Council requirements.

10. Initial Capacity Assessment

10.1 % NBS Assessment

The building's capacity was assessed using the Initial Evaluation Procedure based on the information available. The building's capacity excluding critical structural weaknesses and the capacity of any identified weaknesses are expressed as a percentage of new building standard (%NBS) and are in the order of that shown below in Table 4. These capacities are subject to confirmation by a more detailed quantitative analysis.

Item	%NBS
Building excluding CSW's	15
Plan Irregularity (30% Reduction) Liquefaction Potential (30% Reduction)	7

Table 4 Indicative Building and Critical Structural Weaknesses Capacities based on the NZSEE Initial Evaluation Procedure

Following an IEP assessment, the building has been assessed as achieving 7% New Building Standard (NBS). Under the New Zealand Society for Earthquake Engineering (NZSEE) guidelines the building is considered potentially Earthquake Prone as it achieves less than 34% NBS. This score has not been adjusted when considering damage to the structure as all damage observed was relatively minor and considered unlikely to adversely affect the load carrying capacity of the structural systems.

10.2 Seismic Parameters

The seismic design parameters based on current design requirements from NZS 1170:2002 and the NZBC clause B1 for this building are:

- Site soil class: D, NZS 1170.5:2004, Clause 3.1.3, Soft Soil
- Site hazard factor, Z = 0.3, NZBC, Clause B1 Structure, Amendment 11 effective from 1 August 2011
- Return period factor R_u = 1, NZS 1170.5:2004, Table 3.5, Importance level 2 structure with a 50 year design life.

An increased Z factor of 0.3 for Christchurch has been used in line with requirements from the Department of Building and Housing resulting in a reduced % NBS score.

10.3 Expected Structural Ductility Factor

A structural ductility factor of 1.5 has been assumed based on the structural system observed and the date of construction.

10.4 Discussion of Results

The results obtained from the initial IEP assessment are consistent with those expected for a building of this age and construction type. The building was constructed prior to 1963 and would have been designed to the standards at the time, N.Z.S.S 95:1955. These standards would have used design loads significantly less than those required by current loading standards and lower detailing requirements for ductile seismic behaviour than those that are present in current standards. When combined with the increase in the hazard factor for Christchurch to 0.3, it would be expected that the building would not achieve 100% NBS. Due to the presence of critical structural weaknesses in the form of liquefaction potential and plan irregularity, it is reasonable to expect the building to be classified as potentially Earthquake Prone.

10.5 Occupancy

As the building has been found to have a % NBS less than 34%, it is deemed as potentially Earthquake Prone. It is recommended, as per Christchurch City Council's (CCC) policy regarding occupancy of potentially Earthquake Prone buildings, that the structure is unoccupied pending further detailed assessment and strengthening.

11. Initial Conclusions

The building has been assessed to have a seismic capacity in the order of 7% NBS and is therefore potentially Earthquake Prone in accordance with the NZSEE guidelines. In accordance with CCC policy to not occupy potentially Earthquake Prone buildings, it is recommended that the building is not occupied subject to further investigation and/or strengthening.

12. Recommendations

The recent seismic activity in Christchurch has caused no visible damage to the building. However, as the building has achieved less than 34% NBS following a qualitative Detailed Engineering Evaluation of the building, further assessment is required. It is recommended that a quantitative assessment and geotechnical investigation be carried out and if necessary strengthening options explored.

The building should not be occupied as per CCC policy regarding the occupancy of potentially Earthquake Prone buildings.

13. Limitations

13.1 General

This report has been prepared subject to the following limitations:

- No intrusive structural investigations have been undertaken.
- No intrusive geotechnical investigations have been undertaken.
- No level or verticality surveys have been undertaken.
- No material testing has been undertaken.
- No calculations, other than those included as part of the IEP in the CERA Building Evaluation Report, have been undertaken. No modelling of the building for structural analysis purposes has been performed.

It is noted that this report has been prepared at the request of Christchurch City Council and is intended to be used for their purposes only. GHD accepts no responsibility for any other party or person who relies on the information contained in this reportrite a specific limitations section.

13.2 Geotechnical Limitations

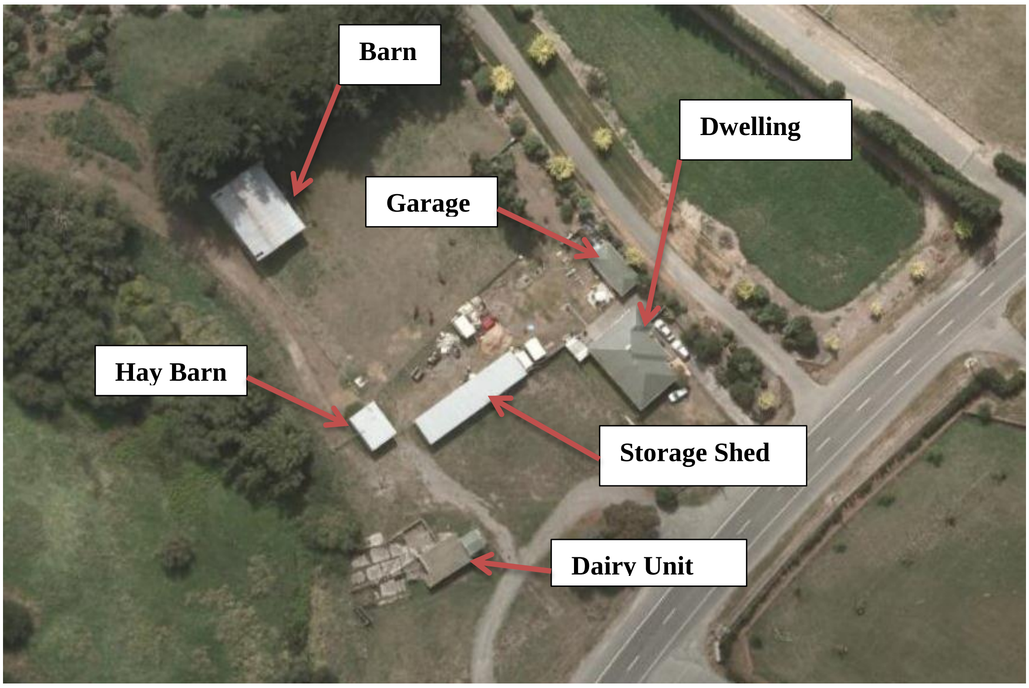
This report presents the results of a geotechnical appraisal prepared for the purpose of this commission, and for prepared solely for the use of Christchurch City Council and their advisors. The data and advice provided herein relate only to the project and structures described herein and must be reviewed by a competent geotechnical engineer before being used for any other purpose. GHD Limited (GHD) accepts no responsibility for other use of the data.

The advice tendered in this report is based on a visual geotechnical appraisal. No subsurface investigations have been conducted. An assessment of the topographical land features have been made based on this information. It is emphasised that Geotechnical conditions may vary substantially across the site from where observations have been made. Subsurface conditions, including groundwater levels can change in a limited distance or time. In evaluation of this report cognisance should be taken of the limitations of this type of investigation.

An understanding of the geotechnical site conditions depends on the integration of many pieces of information, some regional, some site specific, some structure specific and some experienced based. Hence this report should not be altered, amended or abbreviated, issued in part and issued incomplete in any way without prior checking and approval by GHD. GHD accepts no responsibility for any circumstances, which arise from the issue of the report, which have been modified in any way as outlined above.

Appendix A

Photographs



Photograph 1 Aerial photograph of site at 75 Lower Styx Road.

Photograph 2 View of the dairy unit from the north-west. The 1963 extension is to the left and original portion is to the right in this photo. A large opening is clearly visible.

Photograph 3 View of the dairy unit from the southeast.

Photograph 4 View of the dairy unit from the northeast showing the 1963 extension.

Photograph 5 View of the interior at the south-eastern wall of the building. Wall and roof linings and roof joists are clearly visible.

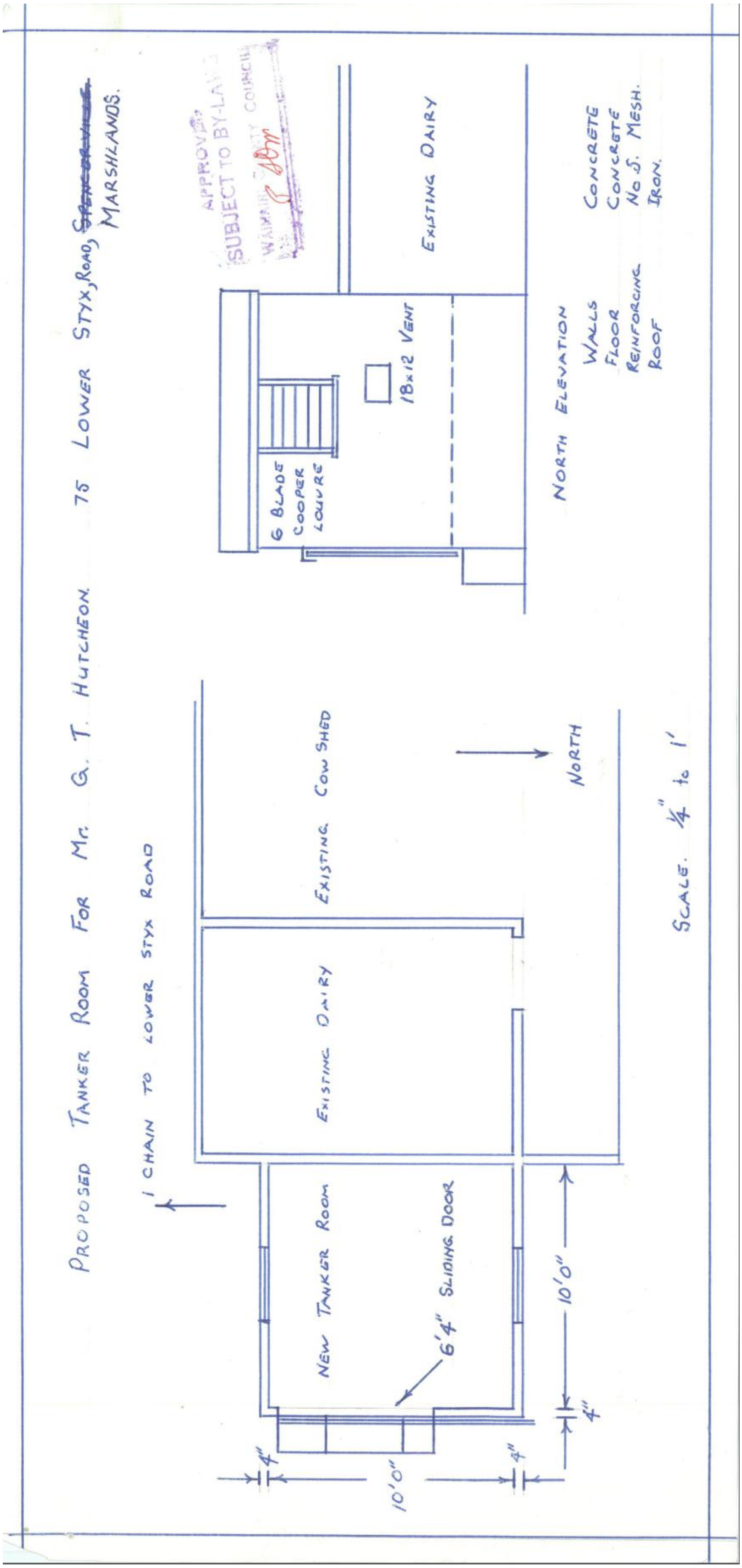
Photograph 6 Cracking to the timber frame lining that is not believed to be earthquake related.

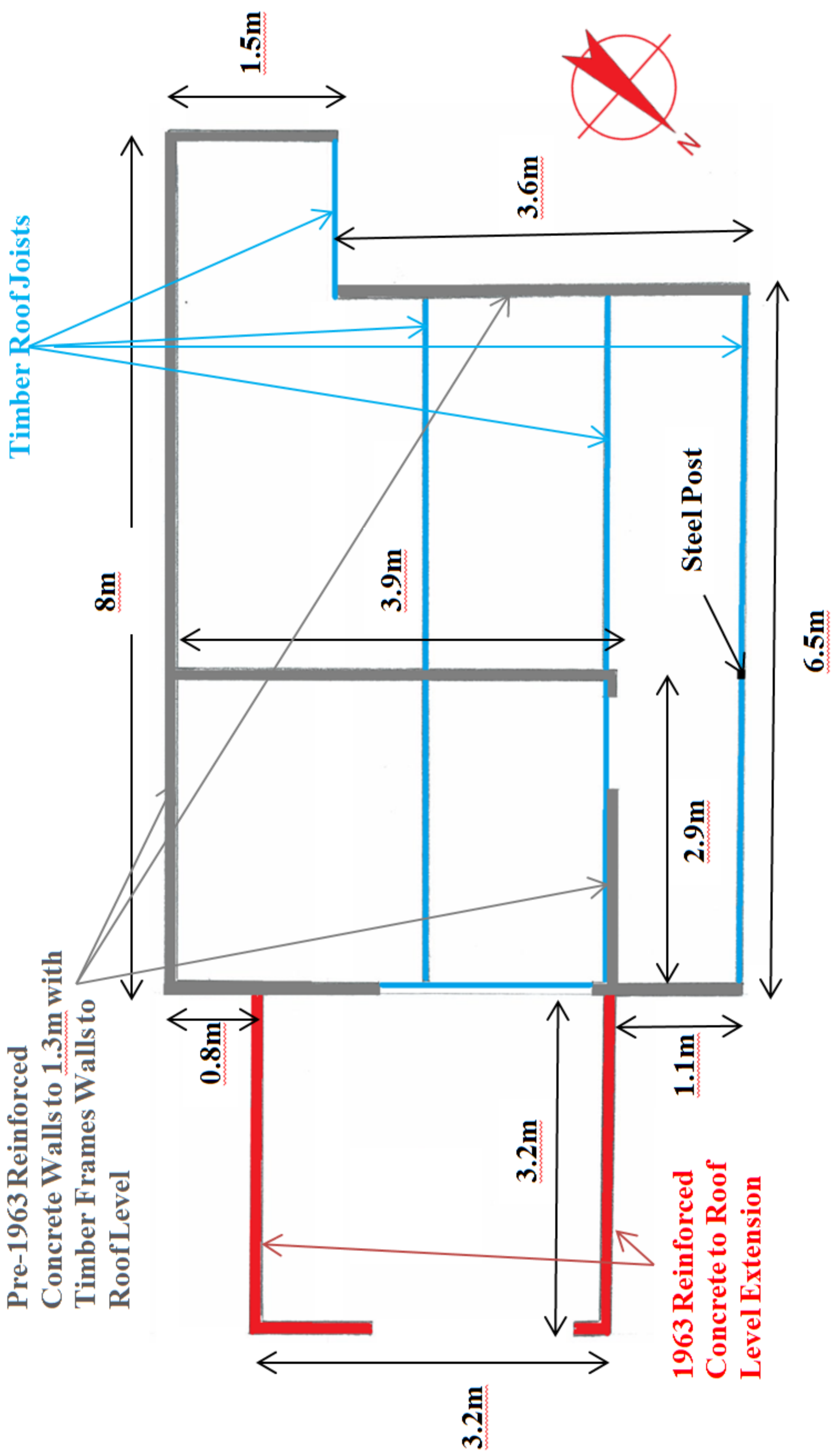
Photograph 7 Timber roof joists in the original portion of the building.

Photograph 8 Interior of the 1963 extension showing opening into the original portion of the building.

Appendix B

Existing Drawings


PROPOSED TANKER ROOM FOR Mr. G. T. HUTCHEON. 75 LOWER STYX, ROAD, MARSHLANDS.
APPROVED SUBJECT TO BY-LAWS
1 CHAIN TO LOWER STYX ROAD
NEW TANKER ROOM
6'4" SLIDING DOOR
10'0"
4"
4"
10'0"
4"
EXISTING DAIRY
EXISTING COW SHED
NORTH
SCALE. 1/4" to 1'
6 BLADE COOPER LOUVRE
18x12 VENT
EXISTING DAIRY
NORTH ELEVATION
WALLS CONCRETE
FLOOR CONCRETE
REINFORCING No. 5. MESH.
ROOF IRON.


1.5m
3.6m
Timber Roof Joists
8m
3.9m
Steel Post
6.5m
2.9m
0.8m
1.1m
3.2m
3.2m
Pre-1963 Reinforced Concrete Walls to 1.3m with Timber Frames Walls to Roof Level
1963 Reinforced Concrete to Roof Level Extension
N

Appendix C

CERA Building Evaluation Form

Detailed Engineering Evaluation Summary Data V1.11

Location

Building Name:	Dairy Unit	Reviewer:	Hamish Mackinven
	Unit / No: / Street	CPEng No:	1003941
Building Address:	75 Lower Styx Road	Company:	GHD
Legal Description:	Lot 1 DP 4410	Company project number:	513059671
		Company phone number:	(03) 3780900
	Degrees / Min / Sec		
GPS south:		Date of submission:	31/05/12
GPS east:		Inspection Date:	16/04/12
		Revision:	FINAL
Building Unique Identifier (CCC):	PRK 2561 BLDG 004 EQ2	Is there a full report with this summary?	yes

Site

Site slope:	flat	Max retaining height (m):	0
Soil type:	mixed	Soil Profile (if available):	Gravel Sand and Silt
Site Class (to NZS1170.5):	D		
Proximity to waterway (m, if <100m):	92	If Ground improvement on site, describe:	n/a
Proximity to clifftop (m, if < 100m):			
Proximity to cliff base (m,if <100m):		Approx site elevation (m):	3.00

Building

No. of storeys above ground:	1 (single storey = 1)	Ground floor elevation (Absolute) (m):	3.92
Ground floor split?	yes	Ground floor elevation above ground (m):	0.92
Storeys below ground	0		
Foundation type:	strip footings	if Foundation type is other, describe:	
Building height (m):	3.60	height from ground to level of uppermost seismic mass (for IEP only) (m):	3.5
Floor footprint area (approx):	46		
Age of Building (years):	49	Date of design:	1935-1965
Strengthening present?	no	If so, when (year)?	
		And what load level (%g)?	
Use (ground floor):	other (specify)	Brief strengthening description:	
Use (upper floors):	other (specify)		
Use notes (if required):	Disused Dairy Unit		
Importance level (to NZS1170.5):	IL2		

Gravity Structure

Gravity System:	load bearing walls		
Roof:	timber framed	rafter type, purlin type and cladding	
Floors:	concrete flat slab	slab thickness (mm)	
Beams:	timber	type	
Columns:	structural steel	typical dimensions (mm x mm)	75x75
Walls:	load bearing concrete	#N/A	

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along:	concrete shear wall	note total length of wall at ground (m):	16
Ductility assumed, μ:	1.50	wall thickness (m):	0.1
Period along:	0.40 (0.04 from parameters in sheet)	estimate or calculation?	estimated
Total deflection (ULS) (mm):		estimate or calculation?	
maximum interstorey deflection (ULS) (mm):		estimate or calculation?	
Lateral system across:	concrete shear wall	note total length of wall at ground (m):	16
Ductility assumed, μ:	1.50	wall thickness (m):	0.1
Period across:	0.40 (0.04 from parameters in sheet)	estimate or calculation?	estimated
Total deflection (ULS) (mm):		estimate or calculation?	
maximum interstorey deflection (ULS) (mm):		estimate or calculation?	

Separations:

leave blank if not relevant

north (mm):	
east (mm):	
south (mm):	
west (mm):	

Non-structural elements

Stairs:			
Wall cladding:	other light	describe	Asbestos
Roof Cladding:	Metal	describe	Corrugated Iron
Glazing:	aluminium frames		
Ceilings:	none		Asbestos
Services(list):			

Available documentation

Architectural	partial	original designer name/date	Unknown, 1963
Structural	none	original designer name/date	
Mechanical	none	original designer name/date	
Electrical	none	original designer name/date	
Geotech report	none	original designer name/date	

Damage

Site: (refer DEE Table 4-2)

Site performance:	Good	Describe damage:	
Settlement:	none observed	notes (if applicable):	
Differential settlement:	none observed	notes (if applicable):	
Liquefaction:	none apparent	notes (if applicable):	
Lateral Spread:	none apparent	notes (if applicable):	
Differential lateral spread:	none apparent	notes (if applicable):	
Ground cracks:	none apparent	notes (if applicable):	
Damage to area:	none apparent	notes (if applicable):	

Building:

	Current Placard Status:	green	
Along	Damage ratio:	0%	Describe how damage ratio arrived at:
	Describe (summary):	No damage	
Across	Damage ratio:	0%	
	Describe (summary):	No damage	
Diaphragms	Damage?:	no	Describe:
CSWs:	Damage?:	no	Describe:
Pounding:	Damage?:	no	Describe:
Non-structural:	Damage?:	no	Describe:

$$Damage\_Ratio = \frac{(\%NBS(before) - \%NBS(after))}{\%NBS(before)}$$

Recommendations

	Level of repair/strengthening required:	none		Describe:
	Building Consent required:	no		Describe:
	Interim occupancy recommendations:	do not occupy		Describe:
Along	Assessed %NBS before:	12%	7% %NBS from IEP below	If IEP not used, please detail assessment methodology:
	Assessed %NBS after:	12%		
Across	Assessed %NBS before:	12%	7% %NBS from IEP below	
	Assessed %NBS after:	12%		

IEP **Use of this method is not mandatory - more detailed analysis may give a different answer, which would take precedence. Do not fill in fields if not using IEP.**

Period of design of building (from above): 1935-1965

h_n from above: 3.5m

Seismic Zone, if designed between 1965 and 1992:

not required for this age of building

not required for this age of building

	along	across
Period (from above):	0.4	0.4
(%NBS)nom from Fig 3.3:	2.9%	2.9%

Note:1 for specifically design public buildings, to the code of the day: pre-1965 = 1.25; 1965-1976, Zone A =1.33; 1965-1976, Zone B = 1.2; all else 1.0	1.00
Note 2: for RC buildings designed between 1976-1984, use 1.2	1.0
Note 3: for buildngs designed prior to 1935 use 0.8, except in Wellington (1.0)	1.0

	along	across
Final (%NBS)$_{nom}$:	**3%**	**3%**

2.2 Near Fault Scaling Factor

Near Fault scaling factor, from NZS1170.5, cl 3.1.6: 1.00

	along	across
Near Fault scaling factor (1/N(T,D), **Factor A**:	1	1

2.3 Hazard Scaling Factor

Hazard factor Z for site from AS1170.5, Table 3.3:	0.30
Z_{1992}, from NZS4203:1992	
Hazard scaling factor, **Factor B:**	3.333333333

2.4 Return Period Scaling Factor

Building Importance level (from above):	2
Return Period Scaling factor from Table 3.1, **Factor C**:	1.00

2.5 Ductility Scaling Factor

	along	across
Assessed ductility (less than max in Table 3.2)	1.50	1.50
Ductility scaling factor: =1 from 1976 onwards; or =kμ, if pre-1976, fromTable 3.3:	1.29	1.29
Ductiity Scaling Factor, **Factor D**:	1.29	1.29

2.6 Structural Performance Scaling Factor:

	along	across
Sp:	0.850	0.850
Structural Performance Scaling Factor **Factor E**:	1.176470588	1.176470588

2.7 Baseline %NBS, (NBS%)$_b$ = (%NBS)$_{nom}$ x A x B x C x D x E

	along	across
%NBS$_b$:	**15%**	**15%**

Global Critical Structural Weaknesses: (refer to NZSEE IEP Table 3.4)

3.1. Plan Irregularity, factor A:	significant	0.7
3.2. Vertical irregularity, Factor B:	insignificant	1
3.3. Short columns, Factor C:	insignificant	1
3.4. Pounding potential	Pounding effect D1, from Table to right	1.0
	Height Difference effect D2, from Table to right	1.0
	Therefore, Factor D:	1
3.5. Site Characteristics	significant	0.7

Table for selection of D1	Severe	Significant	Insignificant/none
Separation	0<sep<.005H	.005<sep<.01H	Sep>.01H
Alignment of floors within 20% of H	**0.7**	**0.8**	**1**
Alignment of floors not within 20% of H	**0.4**	**0.7**	**0.8**

Table for Selection of D2	Severe	Significant	Insignificant/none
Separation	0<sep<.005H	.005<sep<.01H	Sep>.01H
Height difference > 4 storeys	0.4	0.7	1
Height difference 2 to 4 storeys	0.7	0.9	1
Height difference < 2 storeys	1	1	1

3.6. Other factors, Factor F

	Along	Across
For ≤ 3 storeys, max value =2.5, otherwise max valule =1.5, no minimum	1.0	1.0
Rationale for choice of F factor, if not 1		

Detail Critical Structural Weaknesses: (refer to DEE Procedure section 6)

List any: Refer also section 6.3.1 of DEE for discussion of F factor modification for other critical structural weaknesses

3.7. Overall Performance Achievement ratio (PAR)	**0.49**	**0.49**
4.3 PAR x (%NBS)b: PAR x Baselline %NBS:	**7%**	**7%**
4.4 Percentage New Building Standard (%NBS), (before)		**7%**

GHD

Level 4, Spicer Building
148 Victoria Street, Christchurch 8013
T: 64 3 378 0900   F: 64 3 377 8575   E: chcmail@ghd.com

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
FINAL	Peter O'Brien	Hamish Mackinven	[signature]	Donna Bridgman	[signature]	18/12/13